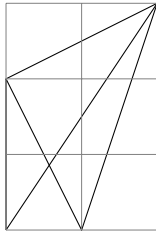


1 SIMPLE STRAIGHT LINES

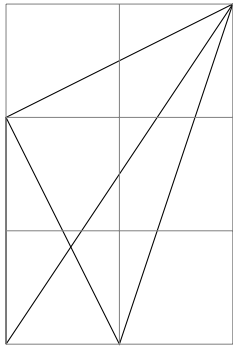


```
\begin{tikzpicture}
  \draw (0,0) -- (1,2);
\end{tikzpicture}
```

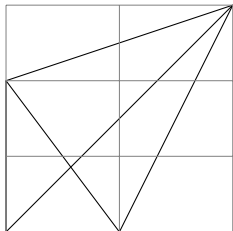


```
\begin{tikzpicture}
  \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
  \draw (0,0) -- (2,3);
  \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

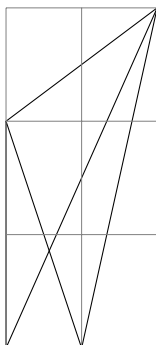
2 SCALING PICTURES



```
\begin{tikzpicture}[scale = 1.5]
  \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
  \draw (0,0) -- (2,3);
  \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```






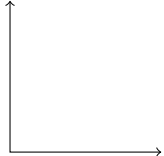
```
\begin{tikzpicture}[xscale = 1.5]
  \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
  \draw (0,0) -- (2,3);
  \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```








```
\begin{tikzpicture}[yscale = 1.5]
  \draw (0,0) -- (0,2) -- (2,3) -- (1,0) -- (0, 2);
  \draw (0,0) -- (2,3);
  \draw[help lines] (0, 0) grid (2, 3);
\end{tikzpicture}
```

3 ARROWS

	<code>\begin{tikzpicture}</code>
	<code>\draw [->] (0,0) -- (2, 0);</code>
	<code>\draw [<-] (0, -0.5) -- (2,-0.5);</code>
	<code>\draw [>] (0,-1) -- (2,-1);</code>
	<code>\end{tikzpicture}</code>

	<code>\begin{tikzpicture}</code>
	<code>\draw [<->] (2, 0) -- (0,0) -- (0,2);</code>
	<code>\end{tikzpicture}</code>

4 CHANGING THICKNESS




	<code>\begin{tikzpicture}</code>
	<code>\draw [ultra thick] (0,1) -- (2, 1);</code>
	<code>\draw [thick] (0,0.5) -- (2,0.5);</code>
	<code>\draw [thin] (0,0) -- (2,0);</code>
	<code>\draw [ultra thin] (0, -0.5) -- (2, -0.5);</code>
	<code>\end{tikzpicture}</code>

Full options include ultra thin, very thin, thin, semithick, thick, very thick, and ultra. Custom widths can also be used.

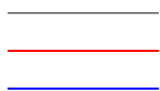


```
\begin{tikzpicture}
\draw [line width = 12] (0, 0) -- (2,2);
\draw [line width = 0.2 cm] (4, 0.75) -- (5, 0.25);
\end{tikzpicture}
```



















5 DASHES AND DOTS

	<code>\begin{tikzpicture}</code>
	<code>\draw [dashed, ultra thick] (0,1) -- (2,1);</code>
	<code>\draw [dashed] (0,0.5) -- (2,0.5);</code>
	<code>\draw [dotted] (0,0) -- (2,0);</code>
	<code>\end{tikzpicture}</code>

6 COLORS



```
\begin{tikzpicture}
\draw [gray, thick] (0,1) -- (2, 1);
\draw [red, thick] (0,0.5) -- (2, 0.5);
\draw [blue, thick] (0,0) -- (2, 0);
\end{tikzpicture}
```

Other colors include red  green  yellow  blue  cyan 
magenta  black  gray  darkgray  lightgray  brown 
lime  olive  orange  pink  purple  teal  violet 
white

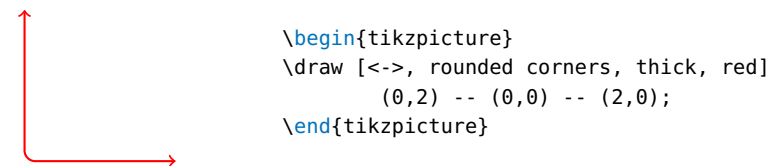
```
\tikz{\draw [<color>, line width = 6] (0,0) -- (0.5, 0);}
```

7 CURVES

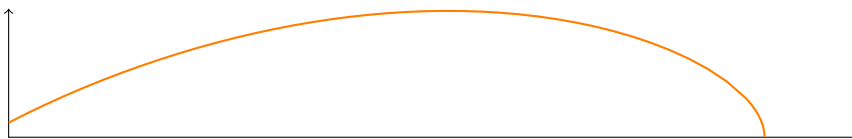


```
\begin{tikzpicture}
\draw [blue] (0,0) rectangle (2,1);
\draw [red, ultra thick] (3, 0.5) circle [radius = 0.5];
\draw [green, thick] (5.5,0.25) arc [radius = 1, start angle = 45,
end angle = 135];
\end{tikzpicture}
```

Arc of radius 1 starts at the point (6,0), leaves it at an angle of 45 degrees and stops when its slope is 135 degrees. To make paths take smoother turns,



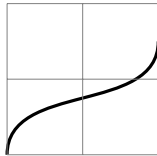
Lots of anchor points can be specified explicitly to make a smoother curve.



```
\begin{tikzpicture}[xscale=25,yscale=5]
\draw [<->] (0.6,1.34) -- (0.6,1) -- (1.05,1);
\draw[orange, thick] (0.6, 1.0385) --
(0.61, 1.06372) -- (0.62, 1.08756) -- (0.63, 1.11012) --
(0.64,1.13147) -- (0.65, 1.15166) -- (0.66, 1.17074) --
(0.67, 1.18874) -- (0.68,1.20568) -- (0.69, 1.22157) --
%[... lots of points ...]
(0.9991, 1.03042) -- (0.9992, 1.02866) -- (0.9993,1.02679) --
(0.9994, 1.02478) -- (0.9995, 1.0226) -- (0.9996, 1.02019) --
(0.9997,1.01747) -- (0.9998, 1.01424) -- (0.9999, 1.01005) --
```

```
(0.9999,1.01005) -- (0.99991, 1.00953) -- (0.99992, 1.00898) --
(0.99993,1.0084) -- (0.99994, 1.00778) -- (0.99995, 1.0071) --
(0.99996,1.00634) -- (0.99997, 1.00549) -- (0.99998, 1.00448) --
(0.99999, 1.00317) -- (1,1) ;
\end{tikzpicture}
```

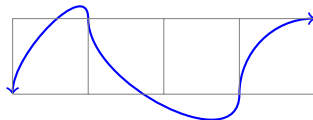
A simpler way to draw a curve is to specify the inlet and exit points, and the inlet and exit angles.



```
\begin{tikzpicture}
\draw[very thick] (0,0) to [out=90,in=195] (2,1.5);
\draw[help lines] (0,0) grid (2,2);
\end{tikzpicture}
```

To decipher the angles,

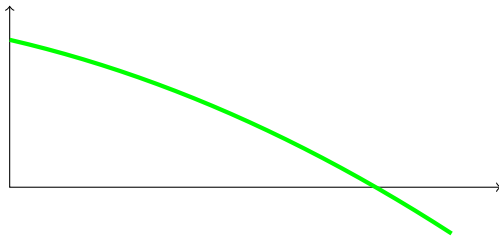
- Draw a vector at the beginning, (0,0) pointing *right* along the base of the figure. Rotate the vector *counterclockwise* until it is tangent with the drawn curve. The angle turned is the out angle.
- Draw a vector at the end, (2, 1.5) pointing to the *left* parallel to the base of the figure. Rotate the vector *counterclockwise* until it is tangent with the drawn curve. The angle turned is the in angle.



```
\begin{tikzpicture}
\draw [<->, thick, blue] (0,0) to [out = 90, in = 90] (1,1) [out =
-90, in = -90] to (3,0) to [out = 90, in = 180] (4,1);
\draw [help lines] (0,0) grid (4,1);
\end{tikzpicture}
```

8 PLOTTING FUNCTIONS

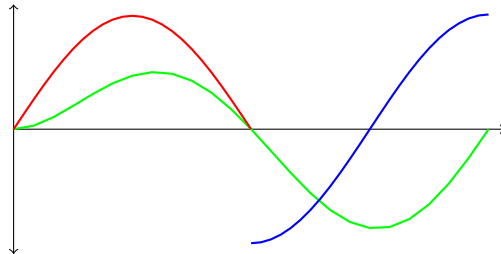
Tikz has a math engine to plot functions.



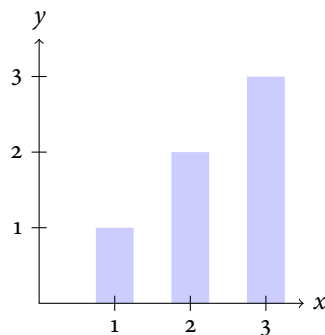
```
\begin{tikzpicture}[xscale = 13, yscale = 3]
\draw [<->] (0, 0.8) -- (0,0) -- (0.5, 0);
\draw [green, ultra thick, domain = 0:0.45]
plot (\x, {0.65 - \x - 2*\x*\x});
\end{tikzpicture}
```

Available functions include `factorial(\x)`, `sqrt(\x)`, `pow(\x,y)` (x^y), `exp(\x)`, `ln(\x)`, `log10(\x)`, `log2(\x)`, `abs(\x)`, `mod(\x,y)`, `round(\x)`, `floor(\x)`, `ceil(\x)`, `sin(\x)`, (`sin(\x r)` for radians), `cos(\x)`, `cos(\x r)`, `tan(\x)`, `tan(\x r)`, `min(\x, y)`, `max(\x, y)`.

These functions can be mixed together, along with two provided constants, $e = 2.718281828$, and $\pi = 3.141592654$.



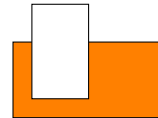
```
\begin{tikzpicture}[yscale=1.5]
\draw [->] (0,0) -- (6.5,0);
\draw [->] (0,-1.1) -- (0,1.1);
\draw [green,domain=0:2*pi] plot (\x, {(sin(\x r)* ln(\x+1))/2});
\draw [red,domain=0:pi] plot (\x, {sin(\x r)});
\draw [blue, domain=pi:2*pi]
plot (\x, {cos(\x r)*exp(\x/exp(2*pi))});
\end{tikzpicture}
```



```
\begin{tikzpicture}
\draw [ycomb, color = blue!20, line width = 0.5 cm]
plot coordinates{(1,1) (2,2) (3,3)};
\draw (1, -0.1) node [below] {1} -- (1, 0.1)
(2, -0.1) node [below] {2} -- (2, 0.1)
(3, -0.1) node [below] {3} -- (3, 0.1);
\foreach \i in {1,2,3}
\draw (-0.1, \i) node [left] {\i} -- (0.1, \i);
\draw [->] (0,3.5) node [above] {$y$}
-- (0,0)
-- (3.5,0) node [right] {$x$} ;
\end{tikzpicture}
```

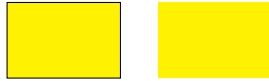
9 FILLING AREAS

Closed paths can be filled.



```
\begin{tikzpicture}
\draw [fill = red, ultra thick] (0,0) rectangle (1,1);
\draw [fill = red, ultra thick, red] (2,0) rectangle (3,1);
\draw [blue, fill = blue] (4,0) -- (5,1) -- (4.75, 0.15) -- (4,0);
\draw [fill] (7, 0.5) circle [radius = 0.1];
\draw [fill = orange] (9,0) rectangle (11,1);
\draw [fill = white] (9.25, 0.25) rectangle (10, 1.5);
\end{tikzpicture}
```

To suppress the outline, replace the `\draw` command with the `\path` command.



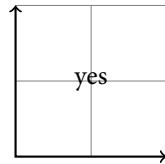
```
\begin{tikzpicture}
\draw [fill = yellow] (0,0) rectangle (1.5,1);
\path [fill = yellow] (2,0) rectangle (3.5,1);
\end{tikzpicture}
```

Mix `--` and `to` to connect arcs and straight lines.



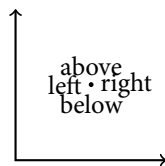
```
\begin{tikzpicture}
\draw [ultra thick] (0,0) to [out = 87, in = 135] (1,1) -- (0.85,
0.15) -- (0,0);
\draw [ultra thick, fill = purple] (2,0) to [out = 87, in = 135]
(3,1) -- (2.85, 0.15) -- (2,0);
\path [fill = purple] (4,0) to [out = 87, in = 135] (5,1) -- (4.85,
0.15) -- (4,0);
\end{tikzpicture}
```

10 LABELS IN PICTURES



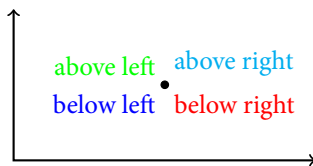
```
\begin{tikzpicture}
\draw [help lines] (0,0) grid (2,2);
\draw [thick, <->] (0,2) -- (0,0) -- (2,0);
\node at (1,1) {yes};
\end{tikzpicture}
```

“yes” is positioned such that the baseline of the text is centered on (1,1). For positioning labels relative to a point,



```
\begin{tikzpicture}
\draw [thick, <->] (0,2) -- (0,0) -- (2,0);
\draw [fill] (1,1) circle [radius = 0.025];
\node [below] at (1,1) {below};
\node [above] at (1,1) {above};
\node [left] at (1,1) {left};
\node [right] at (1,1) {right};
\end{tikzpicture}
```

Compound positioning is also possible,



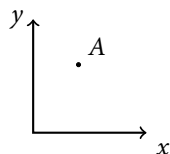
```
\begin{tikzpicture}[scale = 2.0]
```

```

\draw [thick, <->] (0,2) -- (0,0) --(2,0);
\draw [fill] (1,1) circle [radius = 0.025];
\node [below right, red] at (1,1) {below right};
\node [above left, green] at (1,1) {above left};
\node [below left, blue] at (1,1) {below left};
\node [above right, cyan] at (1,1) {above right};
\end{tikzpicture}

```

Labeling axes and points is also easy.

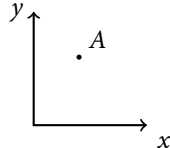


```

\begin{tikzpicture}[scale = 1.5]
\draw [thick, <->] (0,1) -- (0,0) --(1,0);
\node [below right] at (1,0) {$x$};
\node [left] at (0,1) {$y$};
\draw [fill] (0.4, 0.6) circle [radius = 0.5 pt];
\node [above right] at (0.4, 0.6) {$A$};
\end{tikzpicture}

```

Alternatively, nodes can be mixed in the middle of paths.

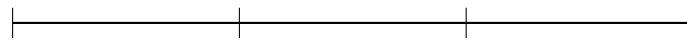


```

\begin{tikzpicture}[scale = 1.5]
\draw [thick, <->] (0,1) node [left] {$y$} -- (0,0)
-- (1,0) node [below right] {$x$};
\draw [fill] (0.4, 0.6) circle [radius = 0.5 pt]
node [above right] (0.4, 0.6) {$A$};
\end{tikzpicture}

```

Multiple lines can be added to nodes with `\`, but alignment of the node text must be explicitly specified.



This is period 1, and is aligned left.	This is period 2, and is aligned center.	This is period 3, and is aligned right.
--	--	---

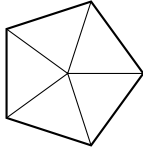
```

\begin{tikzpicture}
\draw [thick] (0,0) to (9,0);
\draw (0, -0.2) to (0, 0.2);
\draw (3, -0.2) to (3, 0.2);
\draw (6, -0.2) to (6, 0.2);
\draw (9, -0.2) to (9, 0.2);
\node[align = left, below] at (1.5, -0.5)
{This is period 1,\and is aligned\left.};
\node[align = center, below] at (4.5, -0.5)
{This is period 2,\and is aligned\center.};
\node[align = right, below] at (7.5, -0.5)
{This is period 3,\and is aligned\right.};
\end{tikzpicture}

```

11 NAMING COORDINATES

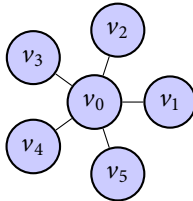
Coordinates can be named with the `\path... \coordinate` command. Non-contiguous line segments can be drawn by omitting the `--` command.



```
\begin{tikzpicture}
\path (0,0) coordinate (origin);
\path (0*72:1 cm) coordinate (P0);
\path (1*72:1 cm) coordinate (P1);
\path (2*72:1 cm) coordinate (P2);
\path (3*72:1 cm) coordinate (P3);
\path (4*72:1 cm) coordinate (P4);

\draw [thick] (P0) -- (P1) -- (P2) -- (P3) -- (P4) -- cycle;
\draw (origin) -- (P0) (origin) -- (P1) (origin) -- (P2)
(origin) -- (P3) (origin) -- (P4);
\end{tikzpicture}
```

12 MORE NODES

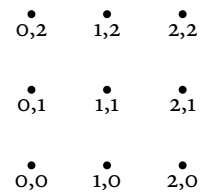


```
\begin{tikzpicture}\tikzset{
every node/.style = {circle, thick, draw, text centered,
fill = blue!20}}

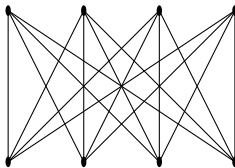
\path (0:0 cm) node (v0) {$v_0$};
\path (0*72:1 cm) node (v1) {$v_1$};
\path (1*72:1 cm) node (v2) {$v_2$};
\path (2*72:1 cm) node (v3) {$v_3$};
\path (3*72:1 cm) node (v4) {$v_4$};
\path (4*72:1 cm) node (v5) {$v_5$};

\draw (v0) -- (v1) (v0) -- (v2) (v0) -- (v3)
(v0) -- (v4) (v0) -- (v5);
\end{tikzpicture}
```

13 LOOPING



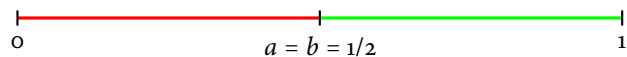
```
\begin{tikzpicture}
\foreach \j in {0,...,2}
\foreach \i in {0,...,2}{
\path (\i,\j) coordinate (x\i\j);
\fill (x\i\j) circle (1.5pt) node [below] {\i,\j};
}
\end{tikzpicture}
```



```
\begin{tikzpicture}[yscale=2]
\foreach \i / \j in {{1/1}, {2/2}, {3/3}, {4/4}}{
\path (\i,0) coordinate (X\i);
\fill (X\i) circle (1pt);
\path (\j,1) coordinate (Y\j);
\fill (Y\j) circle (1pt);
} % Naming coordinates and putting circles
\foreach \i in {1,...,4}
\foreach \j in {1,...,4}
\draw (X\i) -- (Y\j);
% Drawing connections
\end{tikzpicture}
```

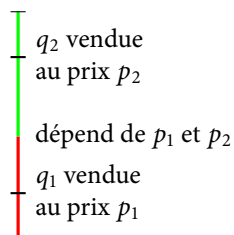

14 EXAMPLES

14.1 Hotelling



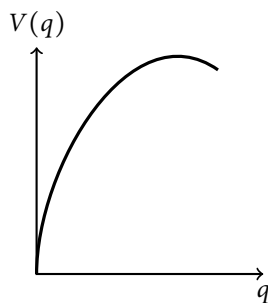
```
\begin{tikzpicture}[xscale = 8]
\draw [red, very thick] (0,0) -- (0.5,0);
\draw [green, very thick] (0.5,0) -- (1,0);
\draw [thick] (0, -0.1) node [below] {0} to (0, 0.1);
\draw [thick] (0.5, -0.1) node [below] {$a=b=1/2$} to (0.5, 0.1);
\draw [thick] (1, -0.1) node [below] {1} to (1, 0.1);
\end{tikzpicture}
```

14.2 Vertical differentiation



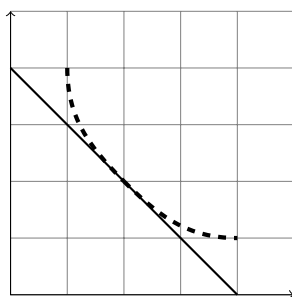
```
\begin{tikzpicture}[yscale=3]
\draw[red, very thick] (0,0) to (0, 0.45);
\draw[green, very thick] (0,0.45) to (0, 1);
\draw (-0.1, 0) to (0.1, 0);
\draw[thick] (-0.1, 0.2) to (0.1, 0.2)
node [align = left, right]
{$q_1$ vendue\au prix $p_1$};
\draw[thick] (-0.1, 0.8) to (0.1, 0.8)
node [align = left, right]
{$q_2$ vendue\au prix $p_2$};
\draw (-0.1, 1) to (0.1, 1);
\node [right] at (0.1, 0.45) {d\'epend de $p_1$ et $p_2$};
\end{tikzpicture}
```

14.3 A curve



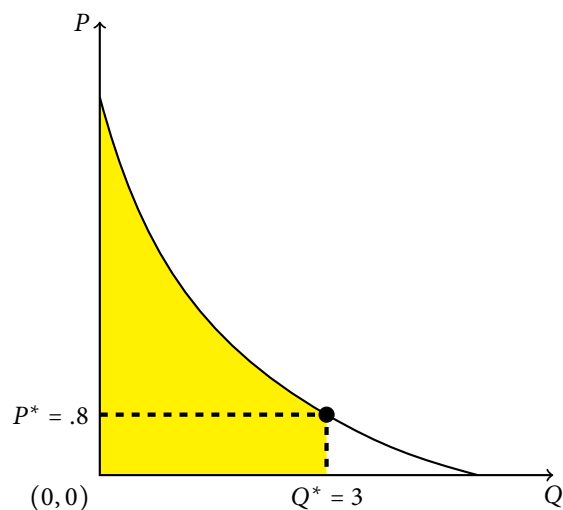
```
\begin{tikzpicture}[scale = 3]
\draw [thick, <->] (0,1) node [left] {$V(q)$}
-- (0,0) -- (1,0) node [below] {$q$};
\draw [very thick] (0,0) to
[out = 90, in = 145] (0.8, 0.9);
\end{tikzpicture}
```

14.4 Tangency



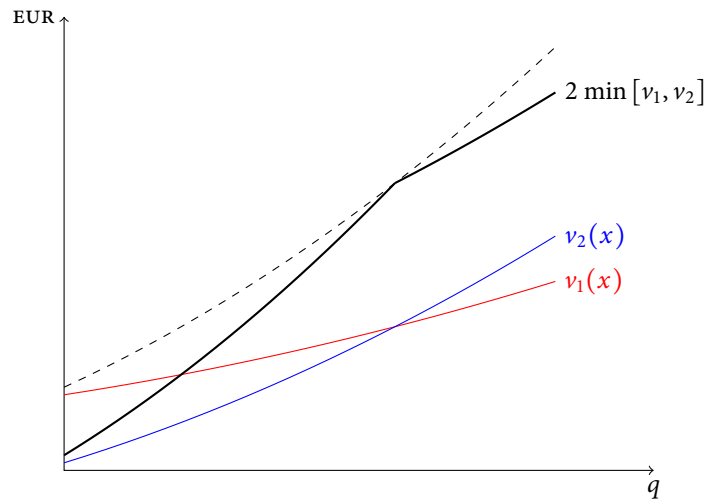
```
\begin{tikzpicture}
\draw [help lines] (0,0) grid (5,5);
\draw [black, <->] (0,5) -- (0,0) -- (5,0);
\draw [thick] (0,4) to (4,0);
\draw [dashed, ultra thick] (1, 4) to
[out = -90, in = 135] (2,2);
\draw [dashed, ultra thick] (2,2) to
[out = -45, in = 180] (4, 1);
\end{tikzpicture}
```

14.5 Consumer surplus



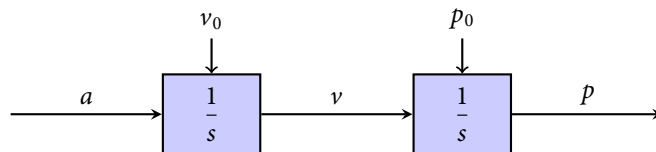
```
\begin{tikzpicture}
\path [fill = yellow] (0,0) to (0,5)
to [out = -75, in = 150] (3,0.8) -- (3,0) -- (0,0);
\draw [thick, <->] (0,6) node [left] {$P$}
-- (0,0) node [below left] {$(0,0)$}
-- (6,0) node [below] {$Q$};
\draw [thick] (0,5) to [out = -75, in = 150] (3,0.8)
to [out = -30, in = 165] (5,0);
\draw [ultra thick, dashed] (0, 0.8) node [left] {$P^* = .8$}
-- (3, 0.8) -- (3,0) node [below] {$Q^* = 3$};
\draw [fill] (3, 0.8) circle [radius = 0.1];
\end{tikzpicture}
```

14.6 Lots of curves



```
\begin{tikzpicture}[domain = 0:0.5, xscale = 13, yscale = 4]
\draw [<->] (0, 2) node [left] {\textsc{eur}}
-- (0,0) -- (0.7, 0) node [below] {$q$};
\draw [red] plot (\x, {0.25+\x/2 + \x*\x/2}) node [right] {$v_1(x)$};
\draw [blue] plot (\x, {0.025 + \x + \x*\x}) node [right] {$v_2(x)$};
\draw [thin, dashed] plot (\x, {0.275 + 1.5*\x + 1.5*\x *\x});
\draw [thick, domain = 0:0.33666] plot (\x, {0.05+2*\x + 2*\x*\x});
\draw [thick, domain = 0.33666:0.5] plot (\x, {0.5 + \x + \x*\x})
node [right] {$2 \text{ min}\left[ v_1, v_2 \right]$};
\end{tikzpicture}
```

14.7 Simple block diagram



```
\begin{tikzpicture}[node distance = 2cm, auto]\tikzset{
block/.style = {rectangle, thick, draw,
text width = 3 em, text centered,
minimum height = 3 em, fill = blue!20},
line/.style = {draw, ->, thick, >=stealth},
init/.style = {pin edge = {to-, thick, black}}}

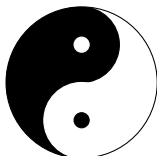
\node [block, pin = {[init] above:$v_0$}]
(a) {$\dfrac{1}{s}$};
\node [left = of a, node distance = 2cm, coordinate] (begin) {};
\node [block, pin = {[init] above:$p_0$}, right = of a]
(c) {$\dfrac{1}{s}$};
\node [right = of c, node distance = 2cm, coordinate] (end) {};
```

```

\path [line] (begin) -- node {$a$} (a);
\path [line] (a) -- node {$v$} (c);
\path [line] (c) -- node {$p$} (end);
\end{tikzpicture}

```

14.8 Yin-yang



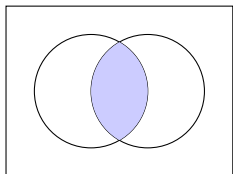
```

\begin{tikzpicture}[scale = 1]
\draw (0,0) circle [radius = 1];
\clip (0,0) circle [radius = 1];
\draw [fill] (-1, -1) rectangle (0,1);

\draw [fill] (0, 0.5) circle [radius = 0.5];
\draw [fill, white] (0, -0.5) circle [radius = 0.5];
\draw [fill] (0, -0.5) circle [radius = 0.1];
\draw [fill, white] (0,0.5) circle [radius = 0.1];
\end{tikzpicture}

```

14.9 Set intersection



```

\begin{tikzpicture}[scale = 0.75]
\draw (-2, 1.5) rectangle (2, -1.5);
\draw (-0.5, 0) circle [radius = 1 cm];
\draw (0.5, 0) circle [radius = 1 cm];
\clip (-0.5, 0) circle [radius = 1 cm];
\clip (0.5, 0) circle [radius = 1 cm];
\draw [fill, blue!20] (-2, 1.5) rectangle (2, -1.5);
\end{tikzpicture}

```